

Monitoring Damage Characteristics in a Filled Elastomer Under Cyclic Loads Using X-Ray Techniques



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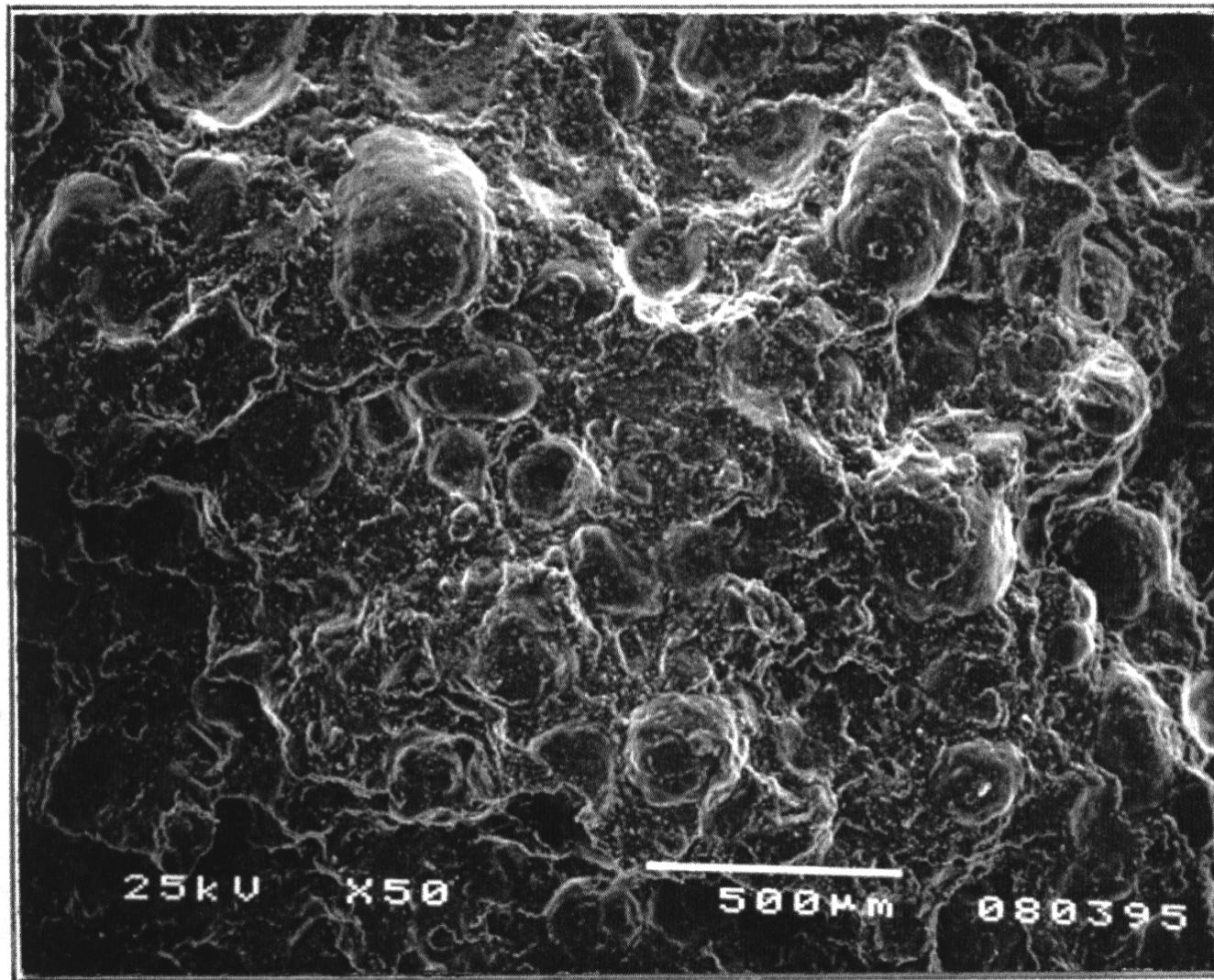


Objectives

- **Investigate the Effect of Loading History on the Damage Characteristics near the Crack Tip.**
- **Loading Conditions: Constant Strain Rate and Cyclic Loading.**



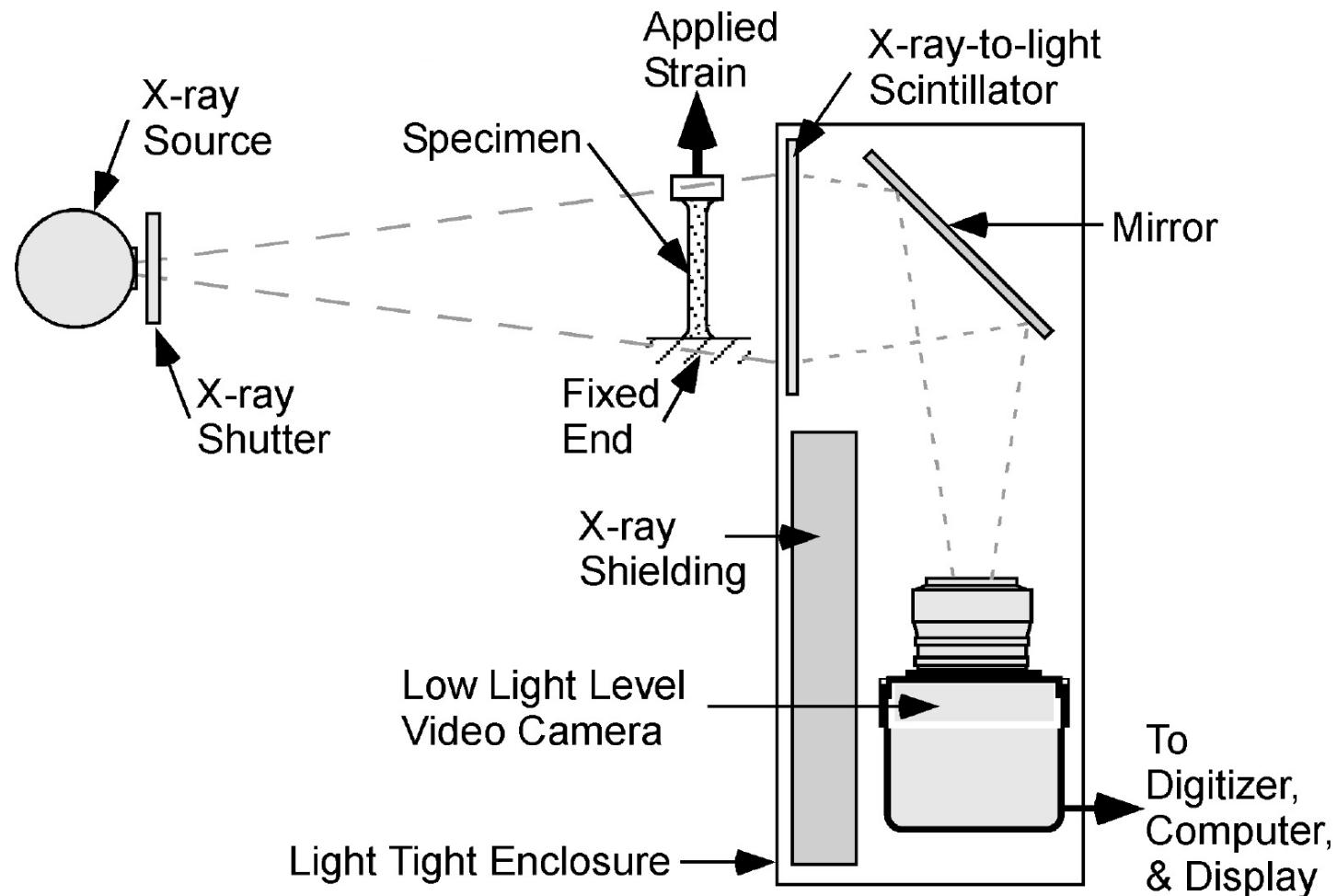
Particulate Composite Material



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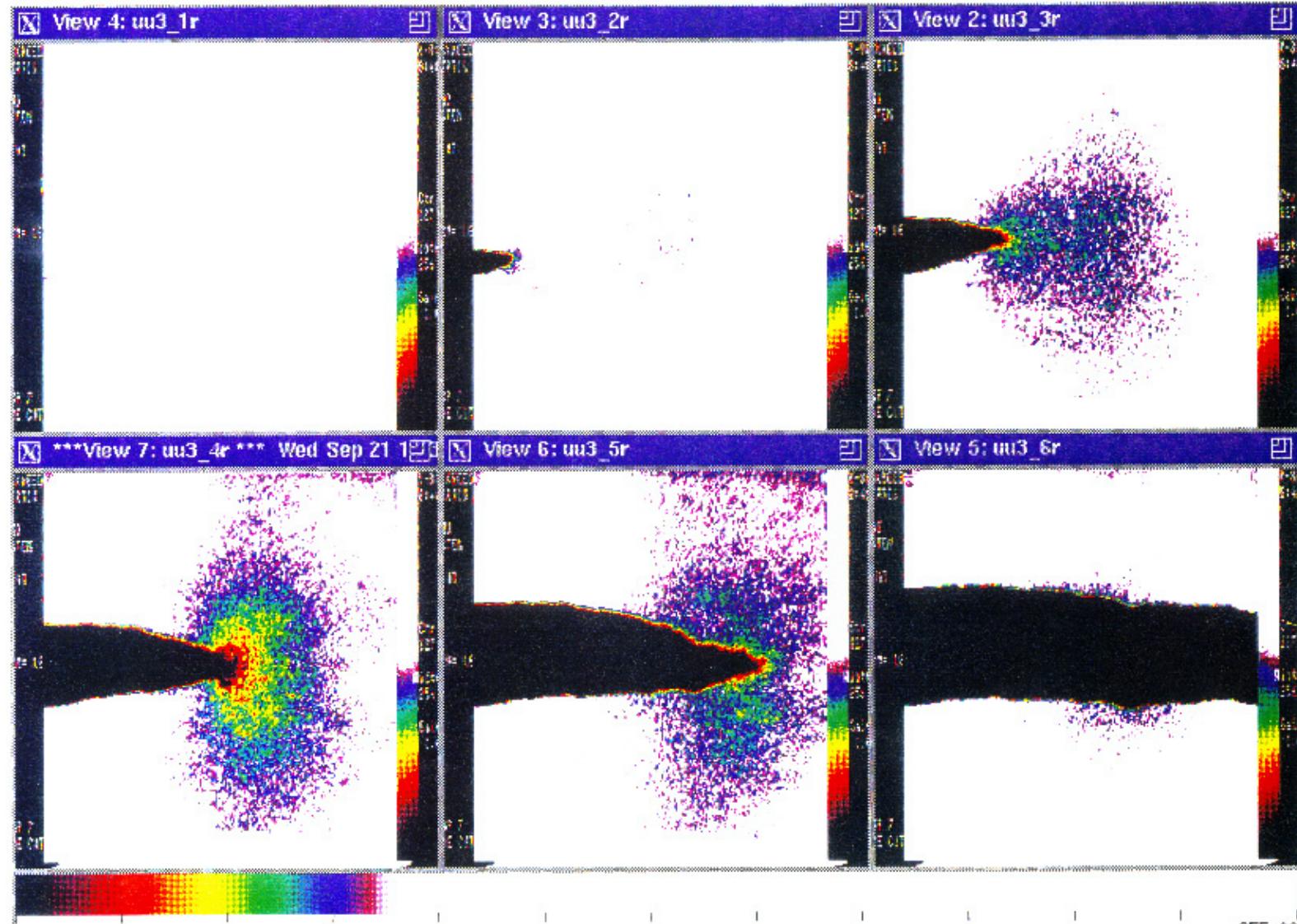


X-Ray Testing Setup





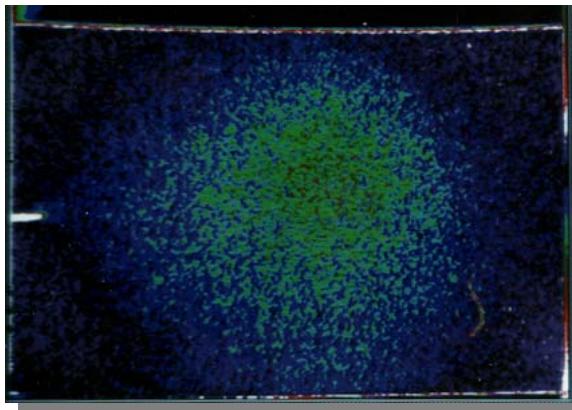
Monitoring Damage Characteristics During Crack Growth in a Specimen Without Pre-Damage



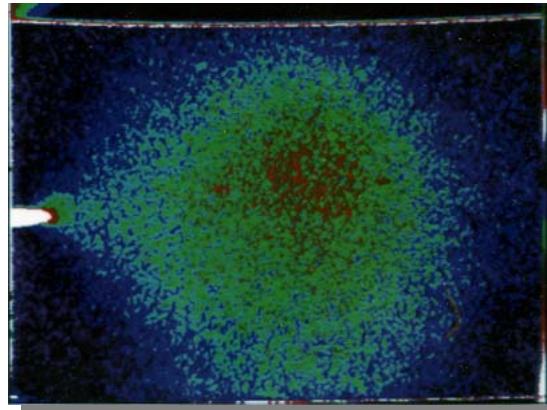
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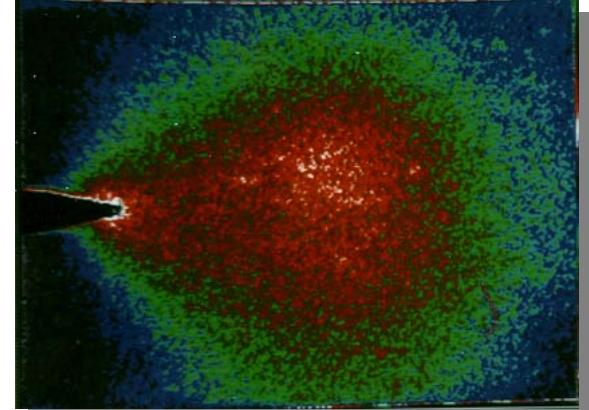
Monitoring Damage Characteristics During Crack Growth in a Specimen With Pre-Damage



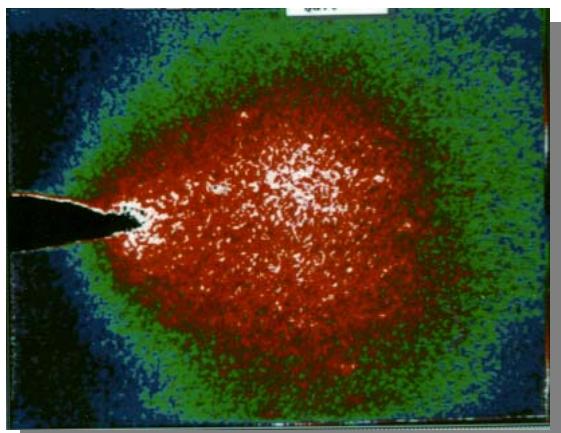
1 Second



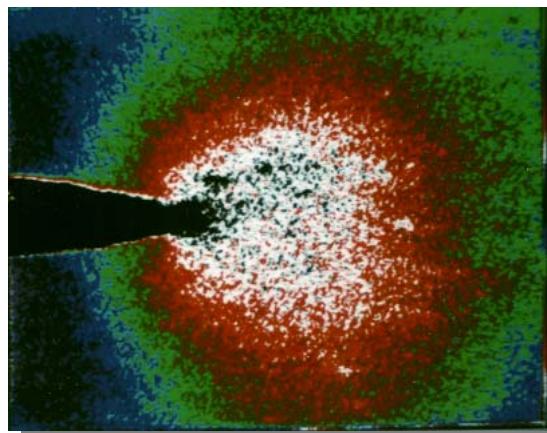
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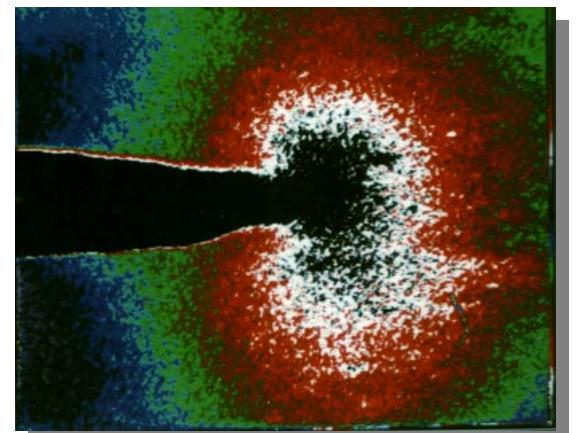
3 Seconds



4 Seconds



5 Seconds



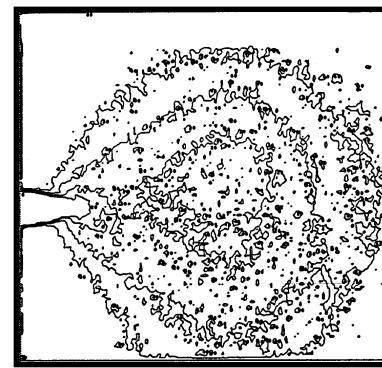
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Monitoring Damage Characteristics During Crack Growth in a Specimen With Pre-Damage

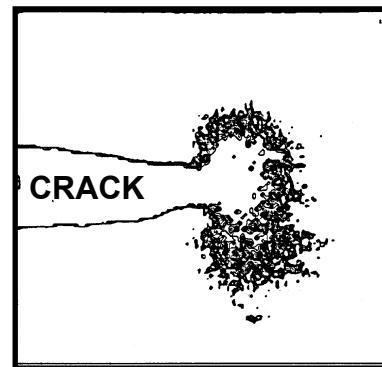


(A) Crack Growth Velocity Decreases When the Crack Enters the Damaged Region



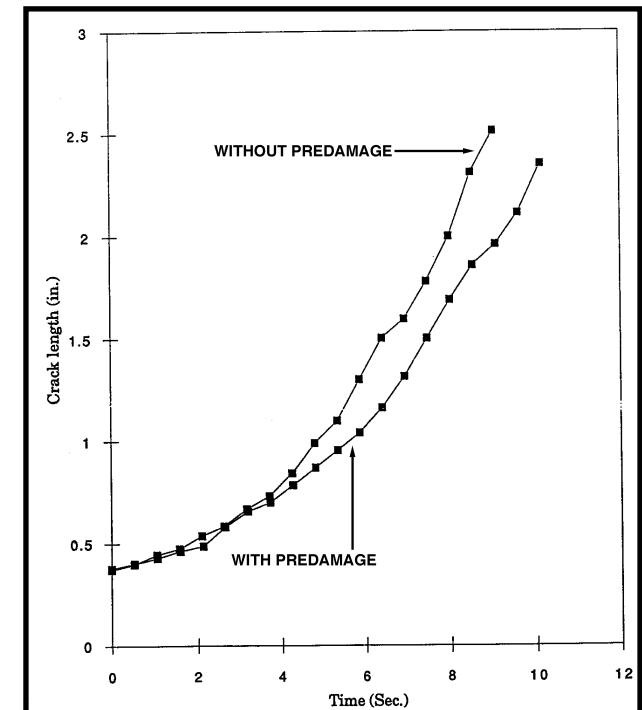
4 SEC.

(B) A Severely Damaged Region has no Significant Effect on Crack Growth Behavior



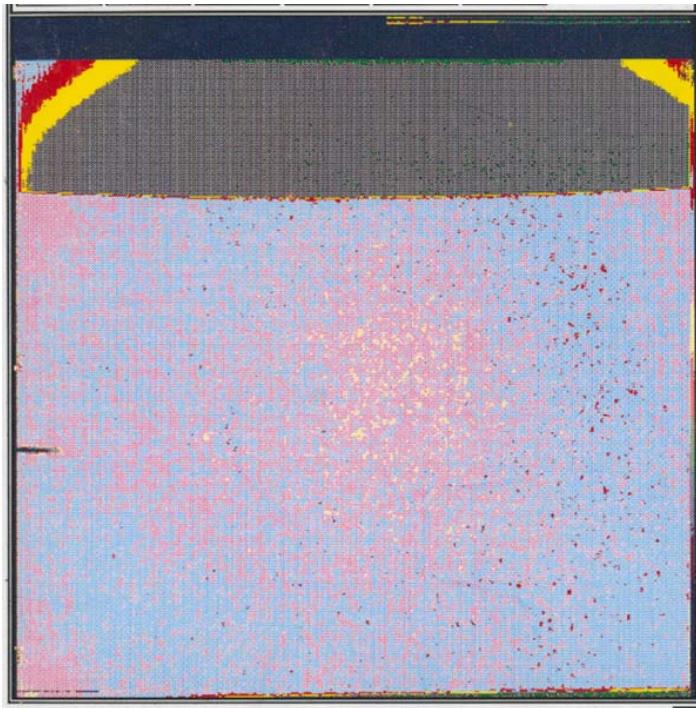
7 SEC.

(C) The Preexisting Damage May Change the Criticality of the Crack

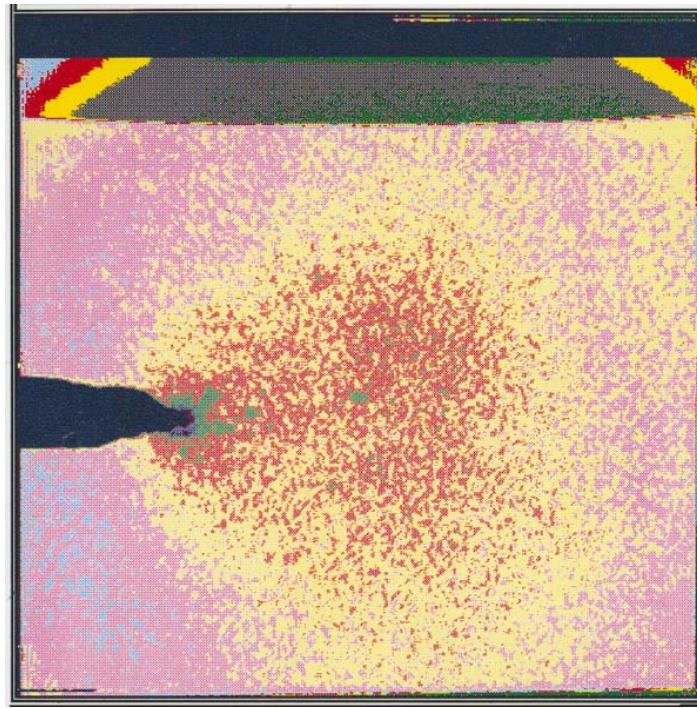




X-Ray Images



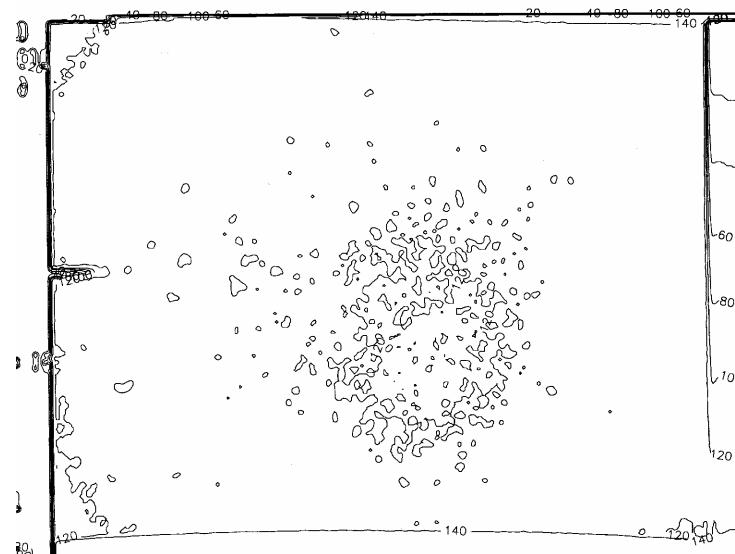
0% / applied strain



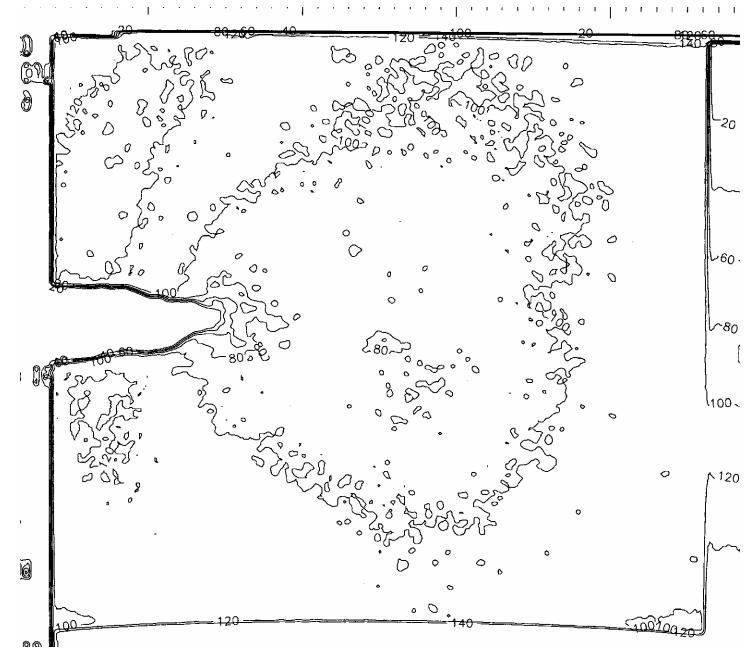
9.5% / applied strain



Iso-intensity Contour Plots of X-Ray Images



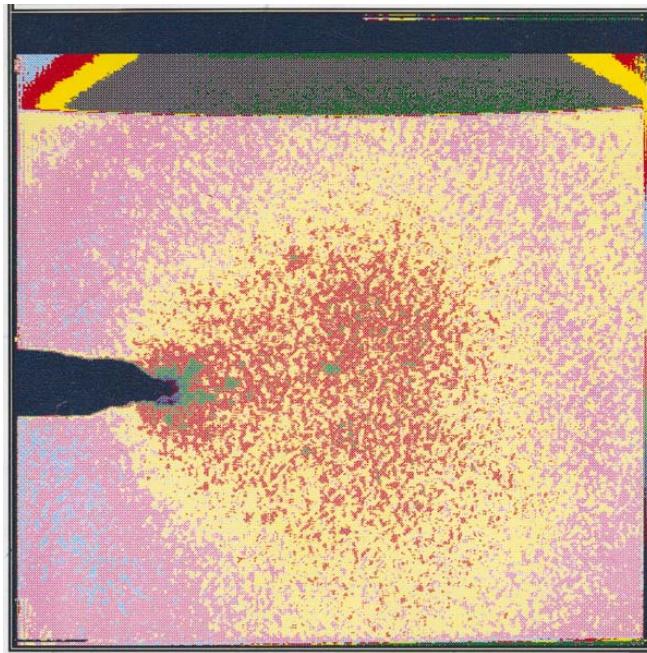
0% / applied strain



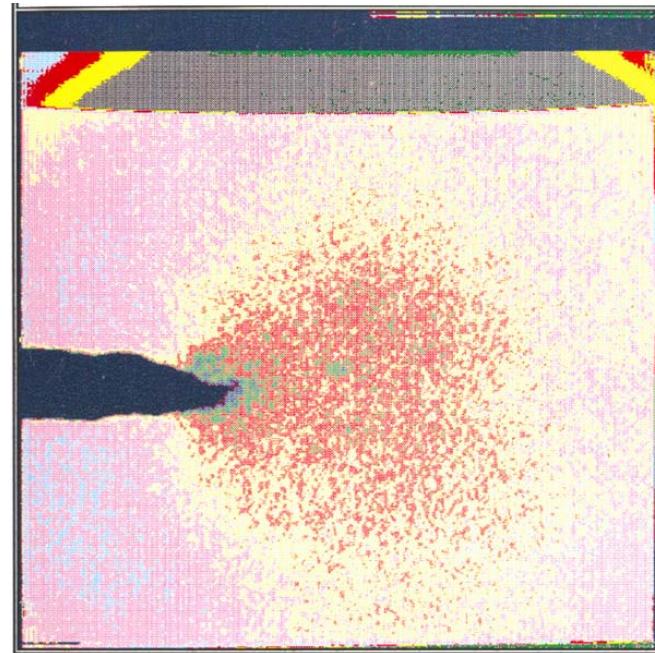
9.5% / applied strain



X-Ray Images (9.5% Applied Strain)



Time = 2 min. 32 sec.

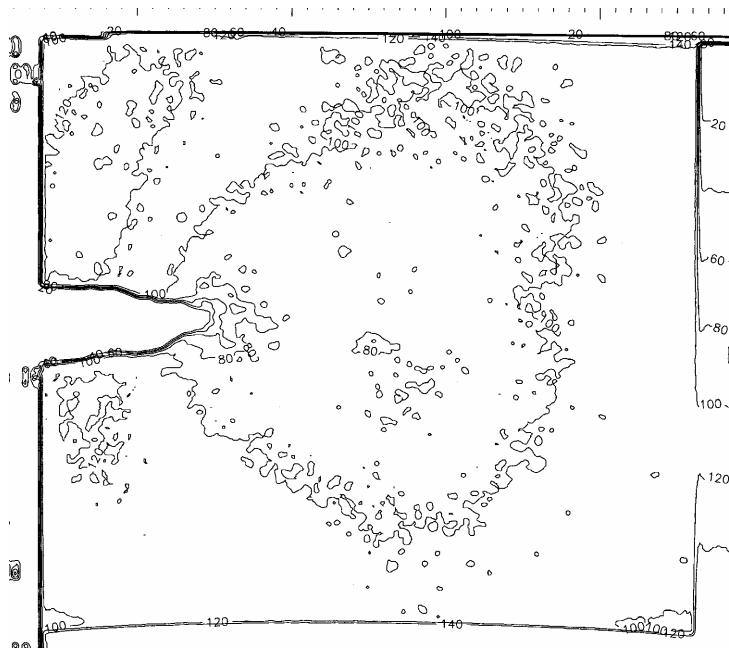


Time = 8 min. 21 sec.

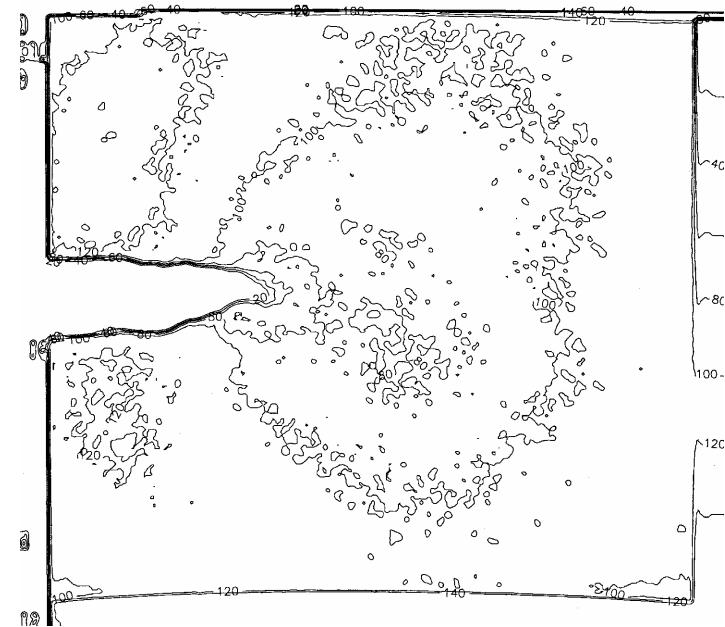
2 min. 32 sec. < 0% applied strain < 8 min. 21 sec



Iso-Intensity Contour Plots of X-Ray Images (9.5% applied strain)



Time = 2 min. 32 sec.

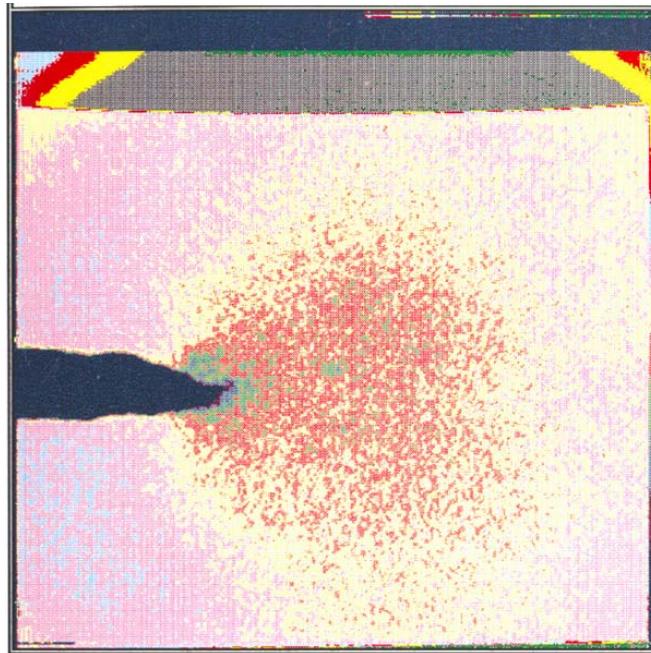


Time = 8 min. 21 sec.

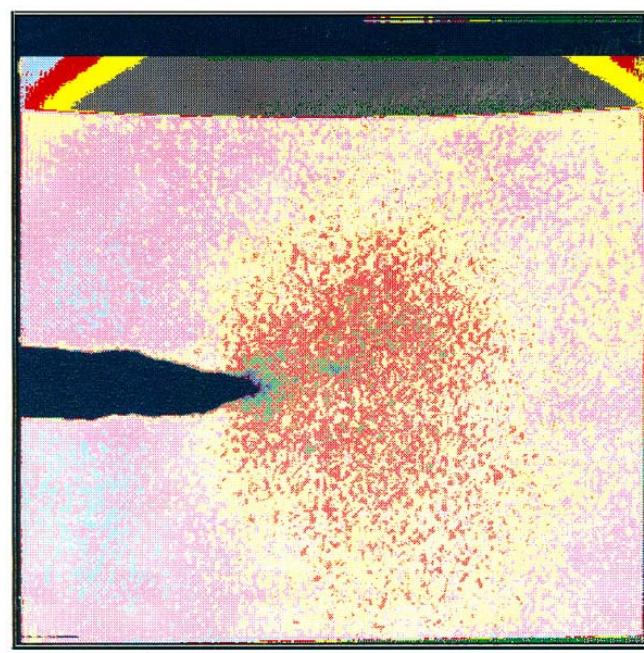
2 min. 32 sec. < 0% applied strain < 8 min. 21 sec



X-Ray Images (9.5% Applied Strain)



Time = 8 min. 21 sec.



Time = 11 min. 5 sec.

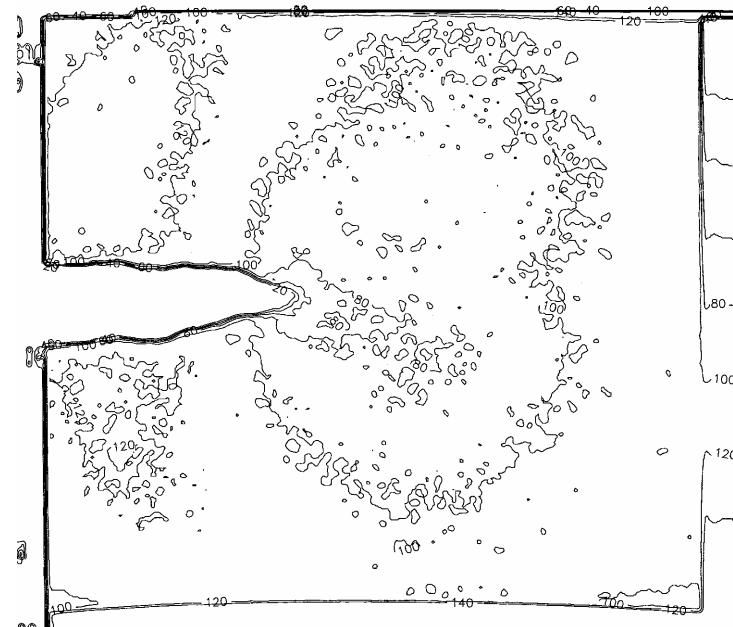
$8 \text{ min. } 21 \text{ sec.} \leq 9.5\% \text{ applied strain} \leq 11 \text{ min. } 5 \text{ sec}$



Iso-intensity Contour Plots of X-Ray Images



Time = 8 min. 21 sec.



Time = 11 min. 5 sec.

8 min. 21 sec. \leq 9.5% applied strain \leq 11min. 5 sec



Conclusions

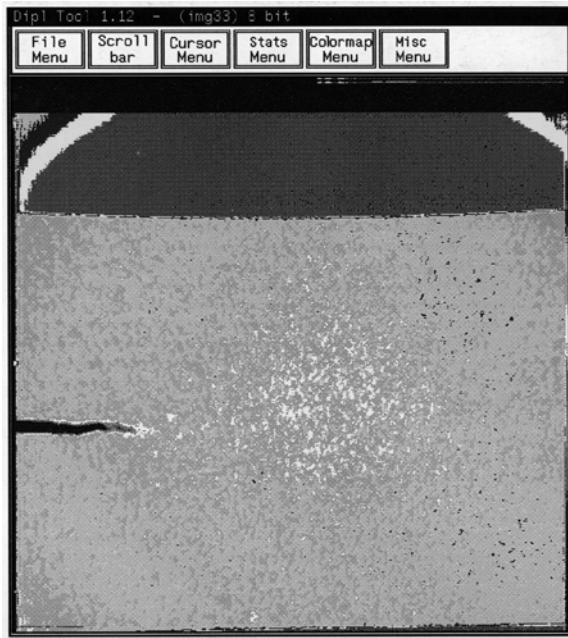
- 1. The damage zone size and the damage intensity in the damage zone are highly dependent on the loading history.**
- 2. Under the constant strain condition the crack propagates.**
- 3. As the applied strain is increased, the damage gradient is decreased and the size of the highly damaged region is increased.**
- 4. The x-ray technique is a promising technique to monitor damage evolution during crack propagation.**



X-Ray Images (second loading cycle)



REPLACE IMAGES W/COLOR

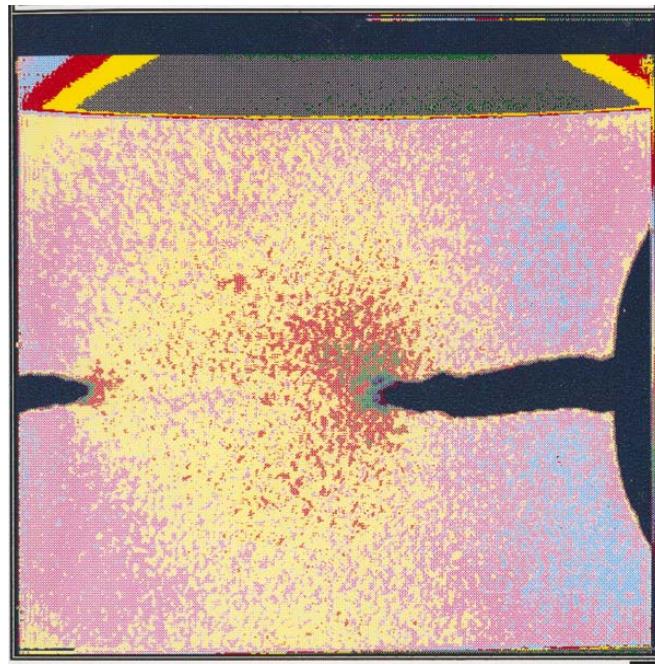


0% / applied strain

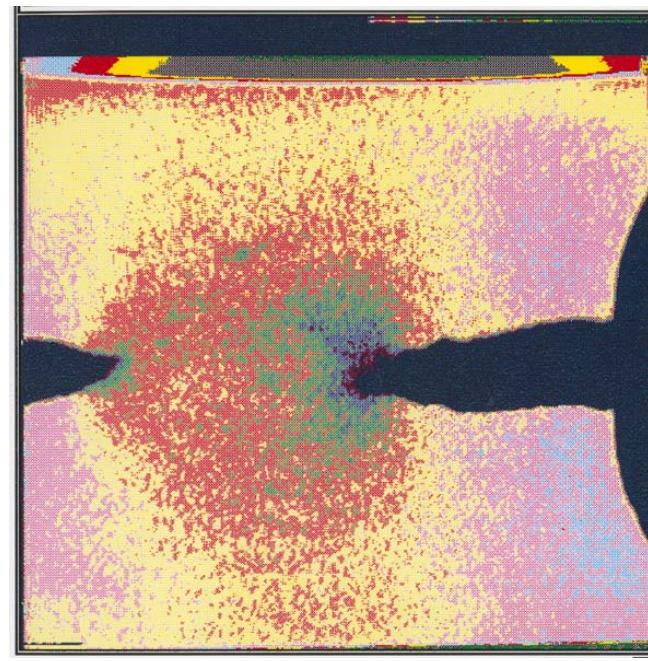
4.55% / applied strain



X-Ray Images (constant strain rate)



Time - 22 min. 8 sec



Time - 22 min. 10 sec



Iso-Intensity Contour Plots of X-Ray Images (constant strain rate)



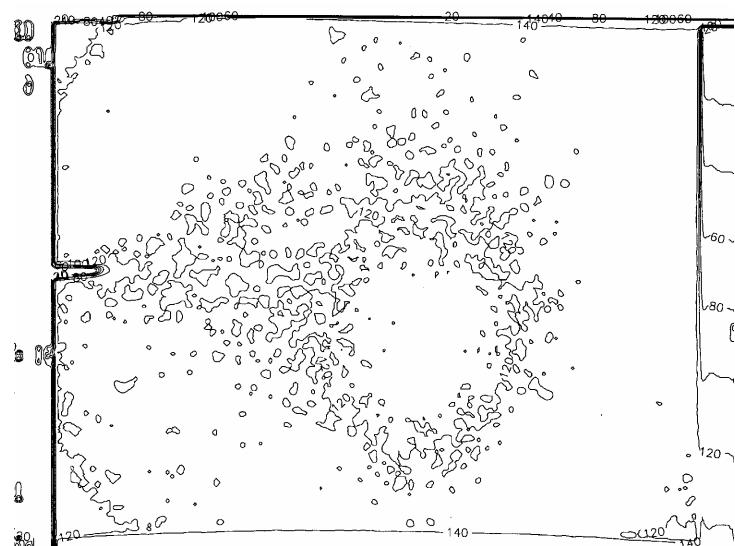
Time - 22 min. 8 sec



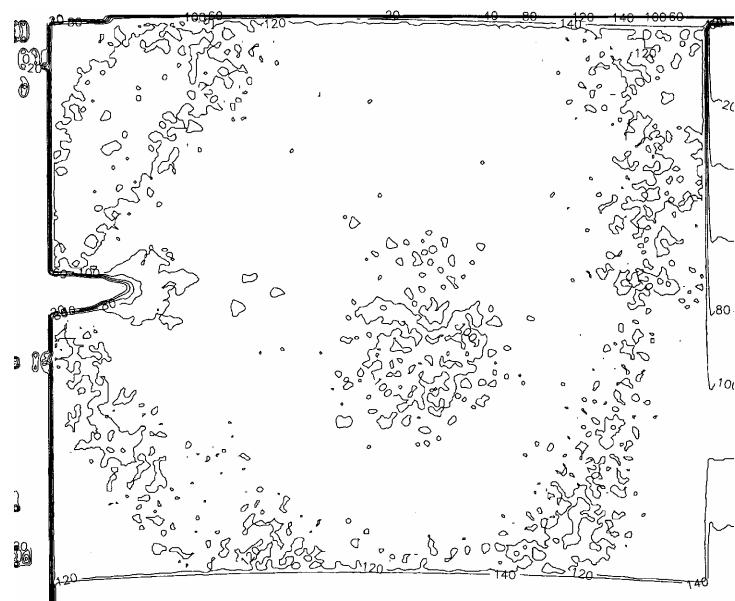
Time - 22 min. 10 sec



Iso-Intensity Contour Plots of X-Ray Images (second loading cycle)



0% / applied strain



4.55% / applied strain